P. Stankus

Adding Pauli Exclusion as an ingredient in MC Glauber

Does it matter?

→ Few-particle 1-D study

- $\langle N_{coll} \rangle$ unchanged
- fluctuations decreased

Exclusion acts as anti-correlation, smoothing out distribution compared to picking out nucleon positions independently.

Project onto position basis

$$P(\vec{r}_1, \vec{r}_2 \ldots) = \left| \underbrace{\langle \Psi(\vec{r}_1, \vec{r}_2 \ldots) |}_{\text{for fermions, needs to be anti-symmetrized}} (\vec{r}_1, \vec{r}_2 \ldots) \rangle \right|^2$$

"Spinless Fermions"

Pure orbitals, common potential

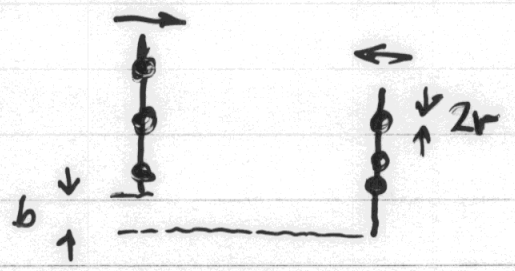
$\varphi_n(\vec{r})$ orbital

$$\Psi(\vec{r}_1, \vec{r}_2) = \varphi_1(\vec{r}_1)\varphi_2(\vec{r}_2) - \varphi_1(\vec{r}_2)\varphi_2(\vec{r}_1)$$

generally $= \left| \varphi_m(\vec{r}_n) \right|$

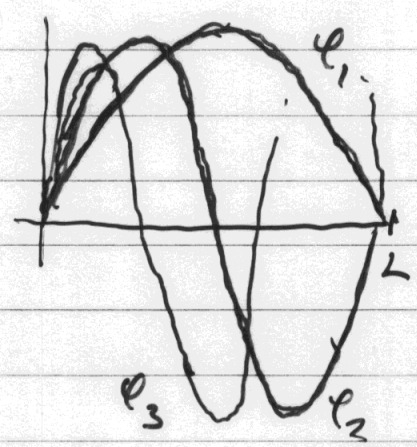
Simplest possible example

One-dimensional "nuclei" colliding in 2-D space



Single-particle 1-D box orbitals

$$\varphi_n(x) \propto \sin \frac{n\pi x}{L}$$

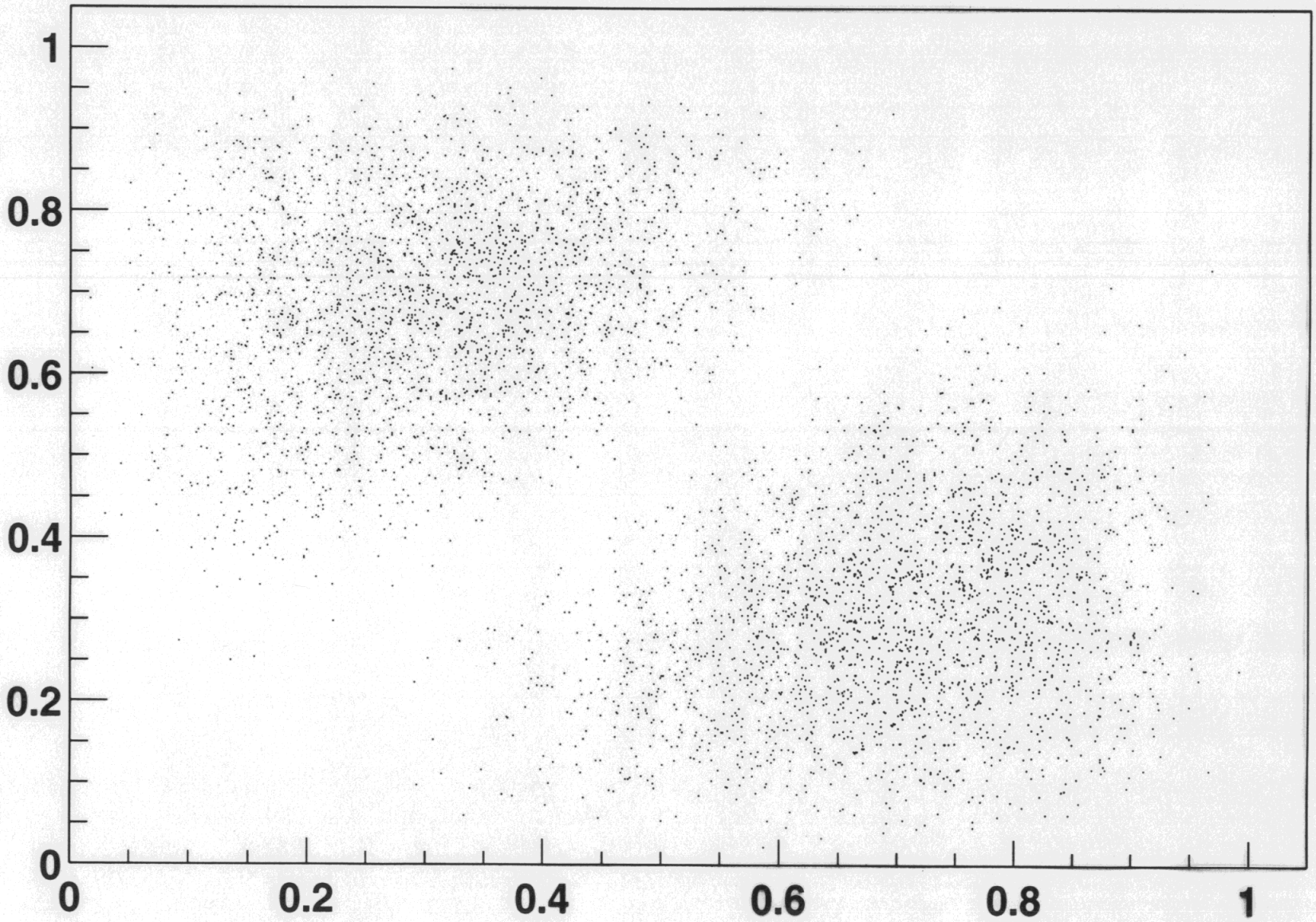


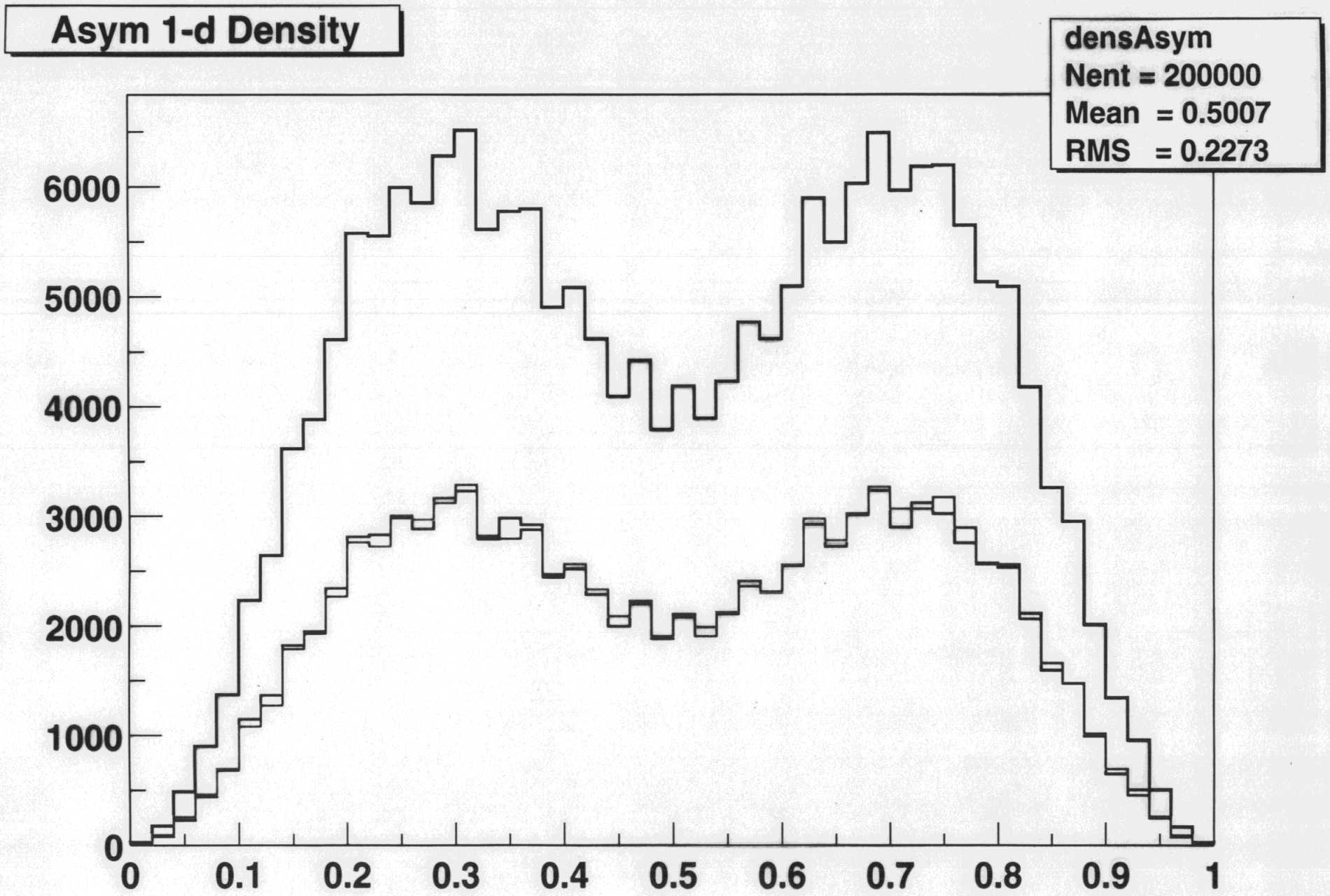
3 assumptions:

1. Fully anti symmetrized
2. Non-symmetrized
3. Independent

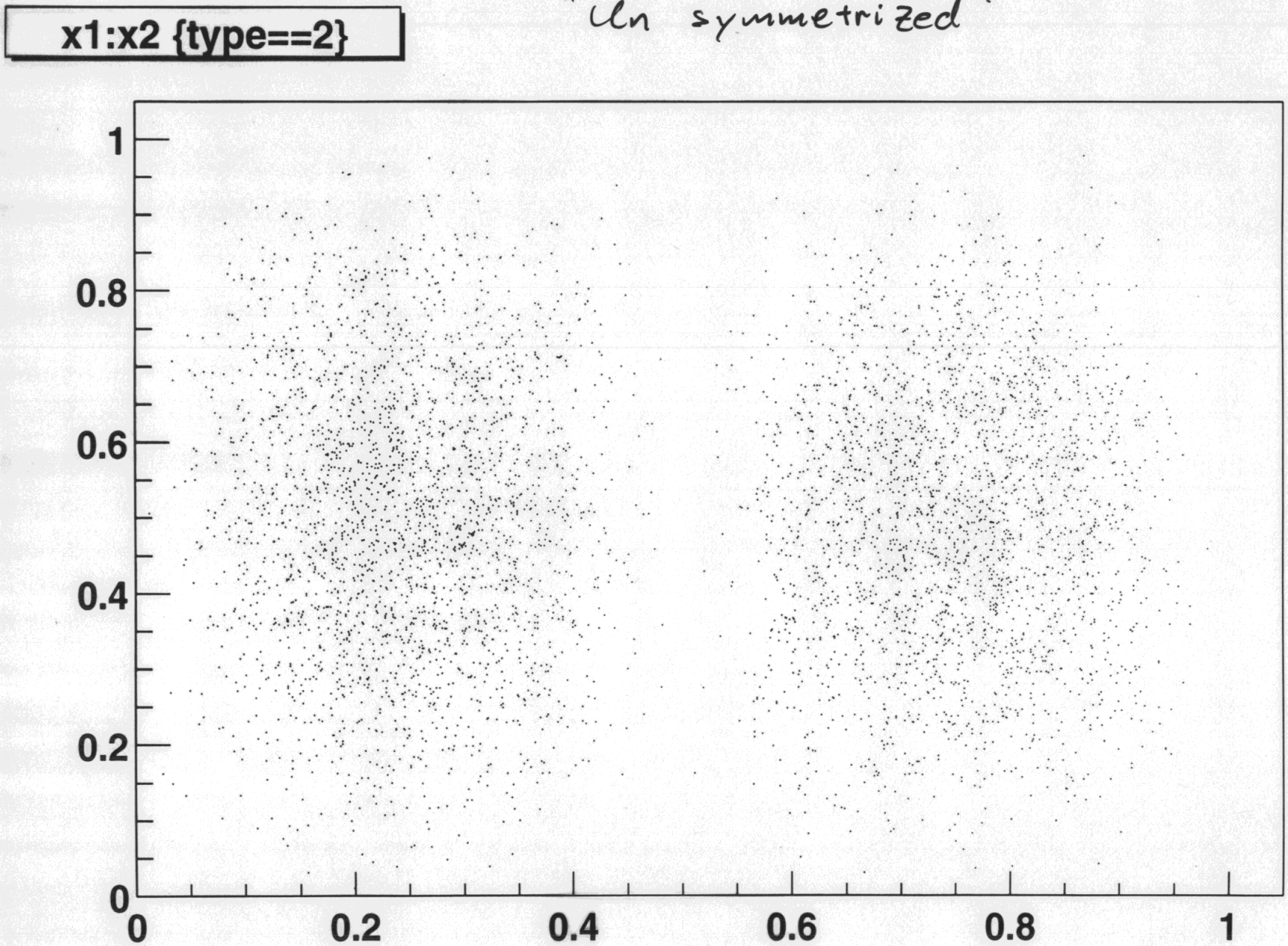
x1:x2 {type==1}

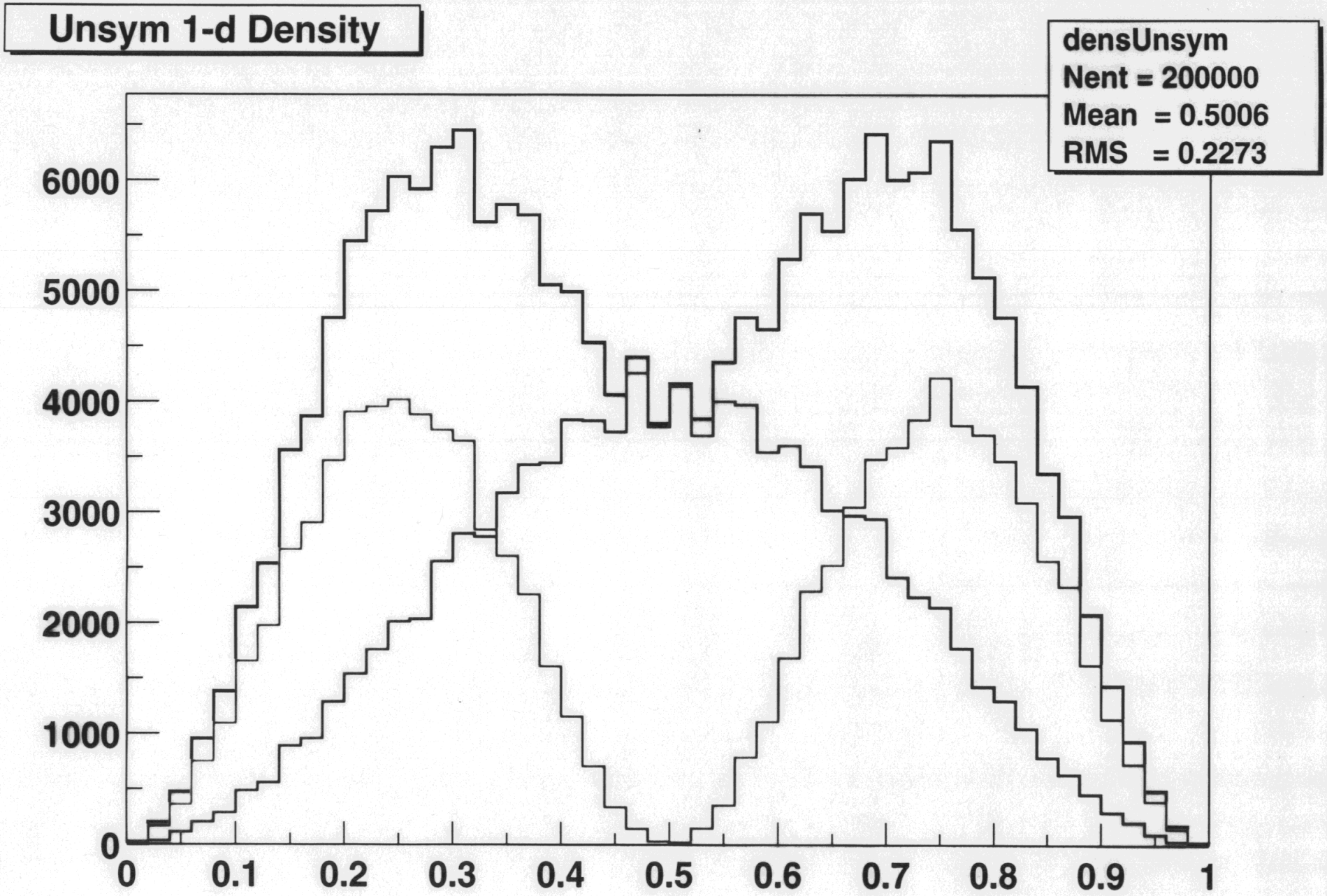
Fully anti symmetrized

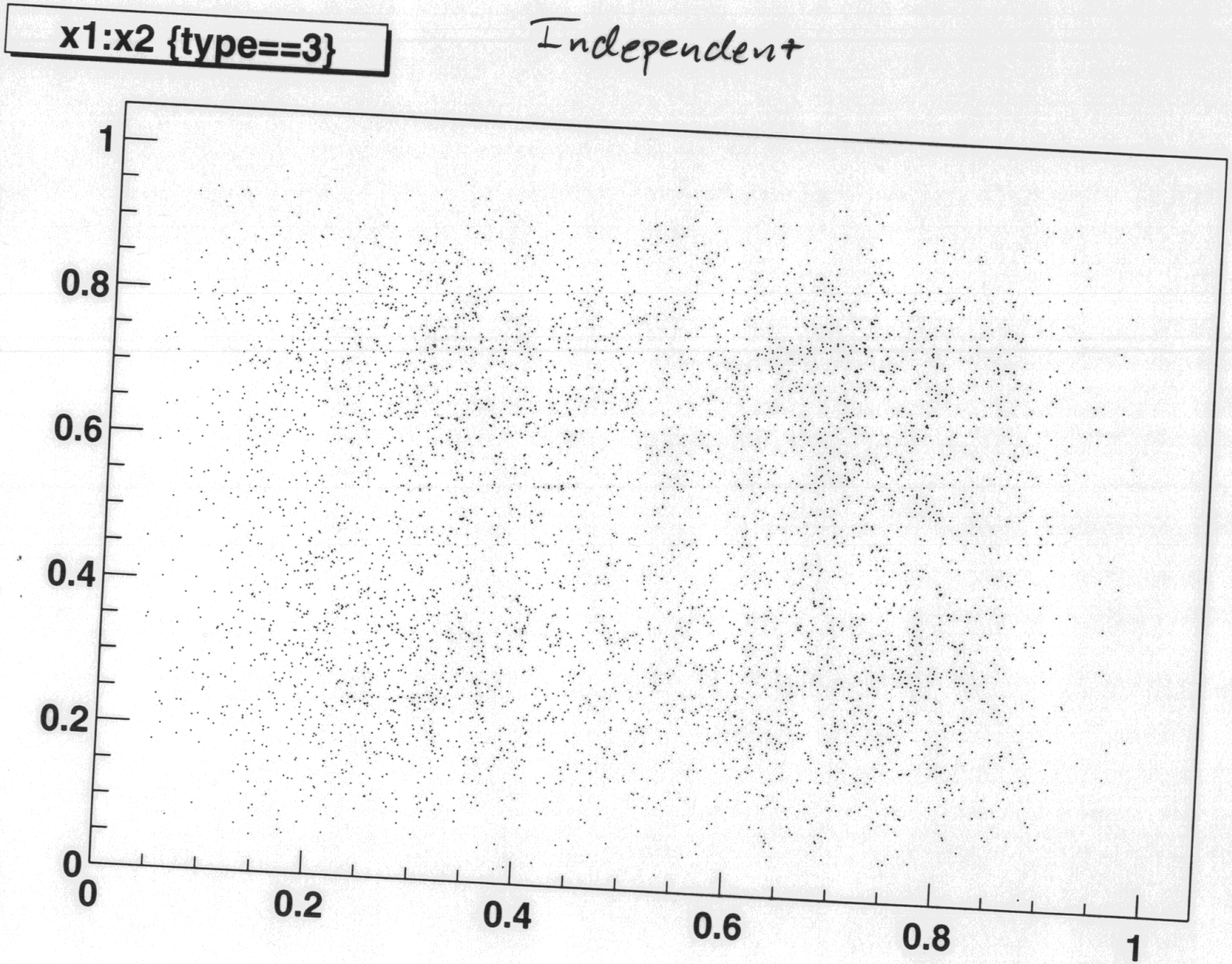


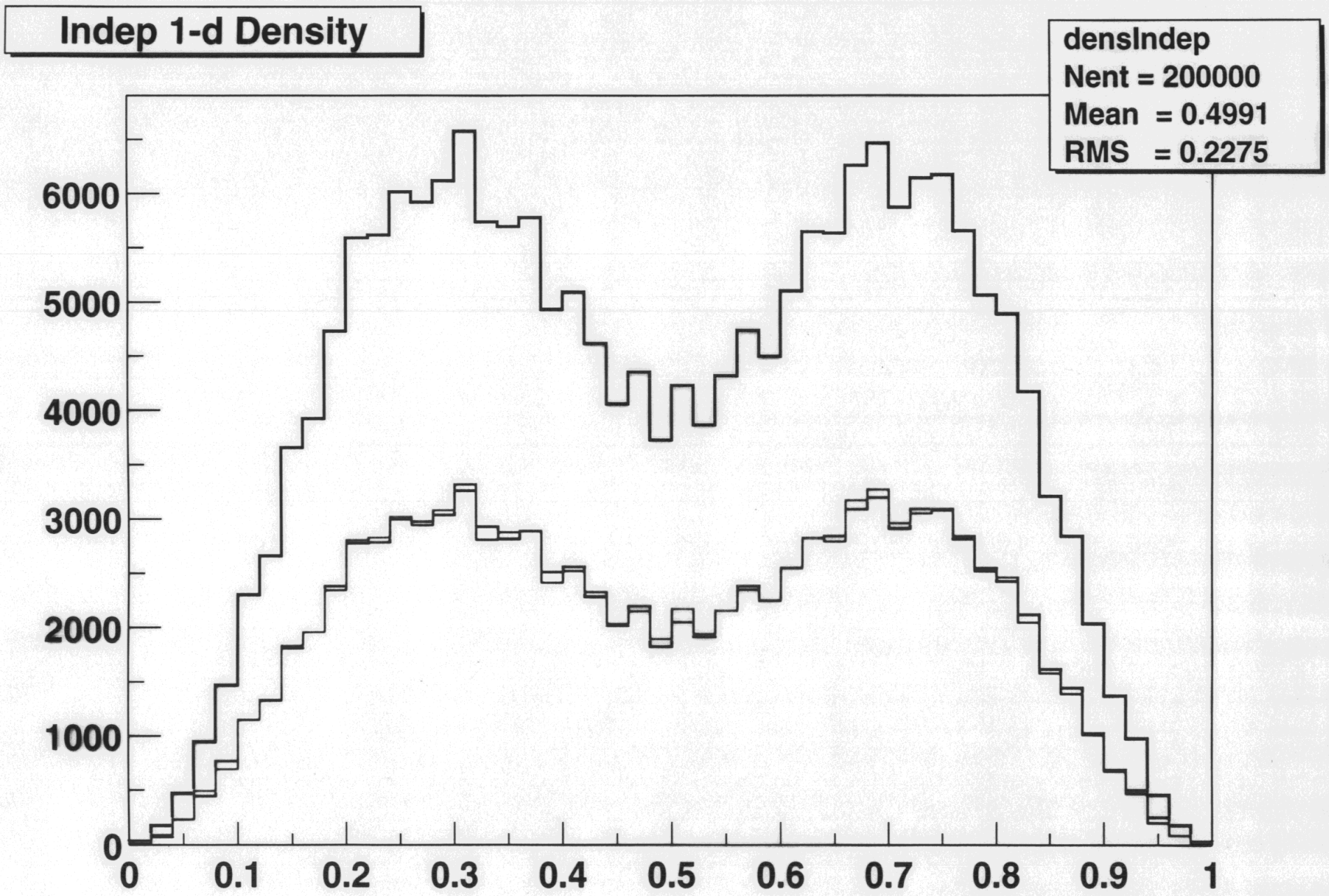

Asym 1-d Density
densAsym
Nent = 200000
Mean = 0.5007
RMS = 0.2273
6000
5000
4000
3000
2000
1000
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

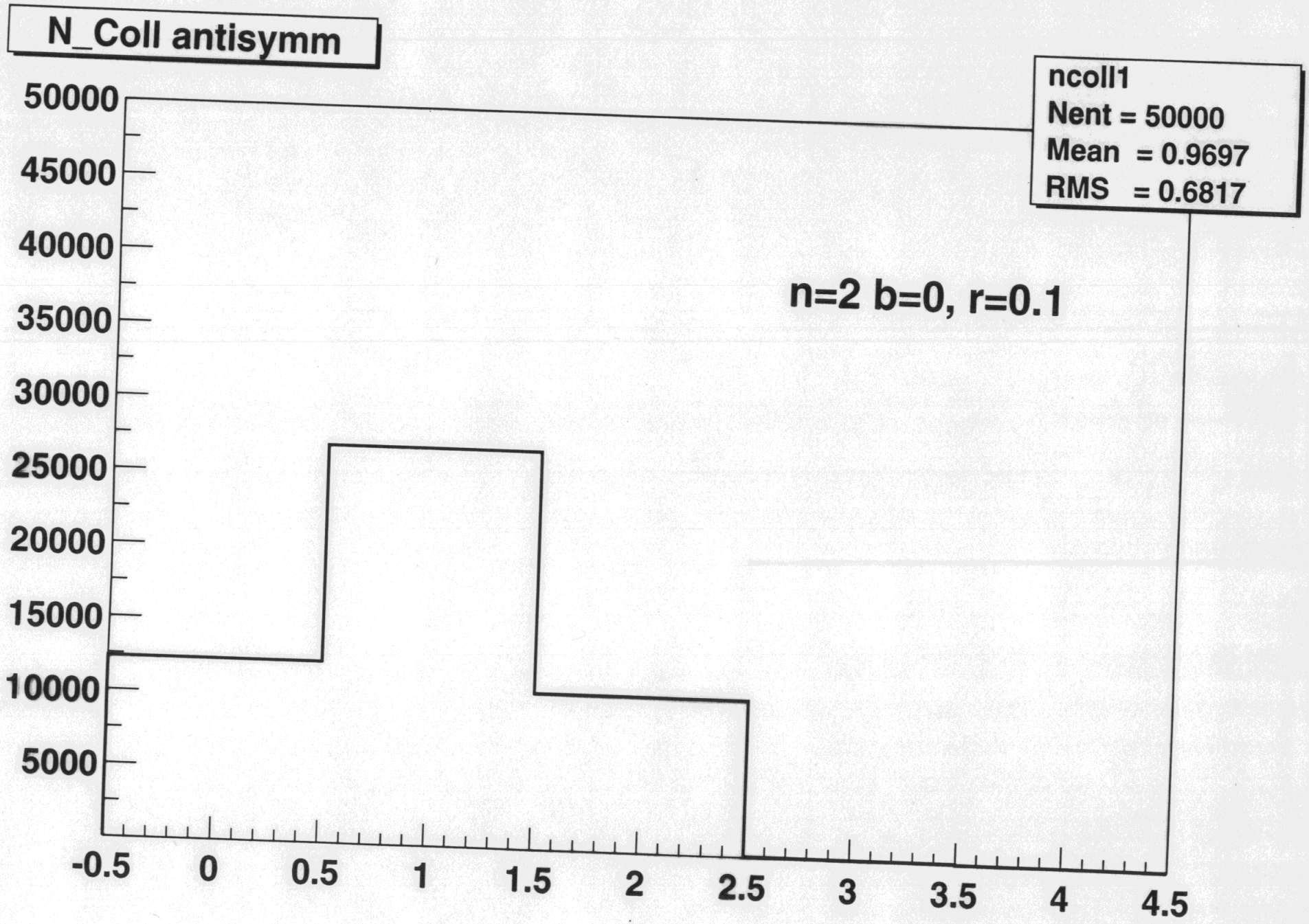
"Un symmetrized"

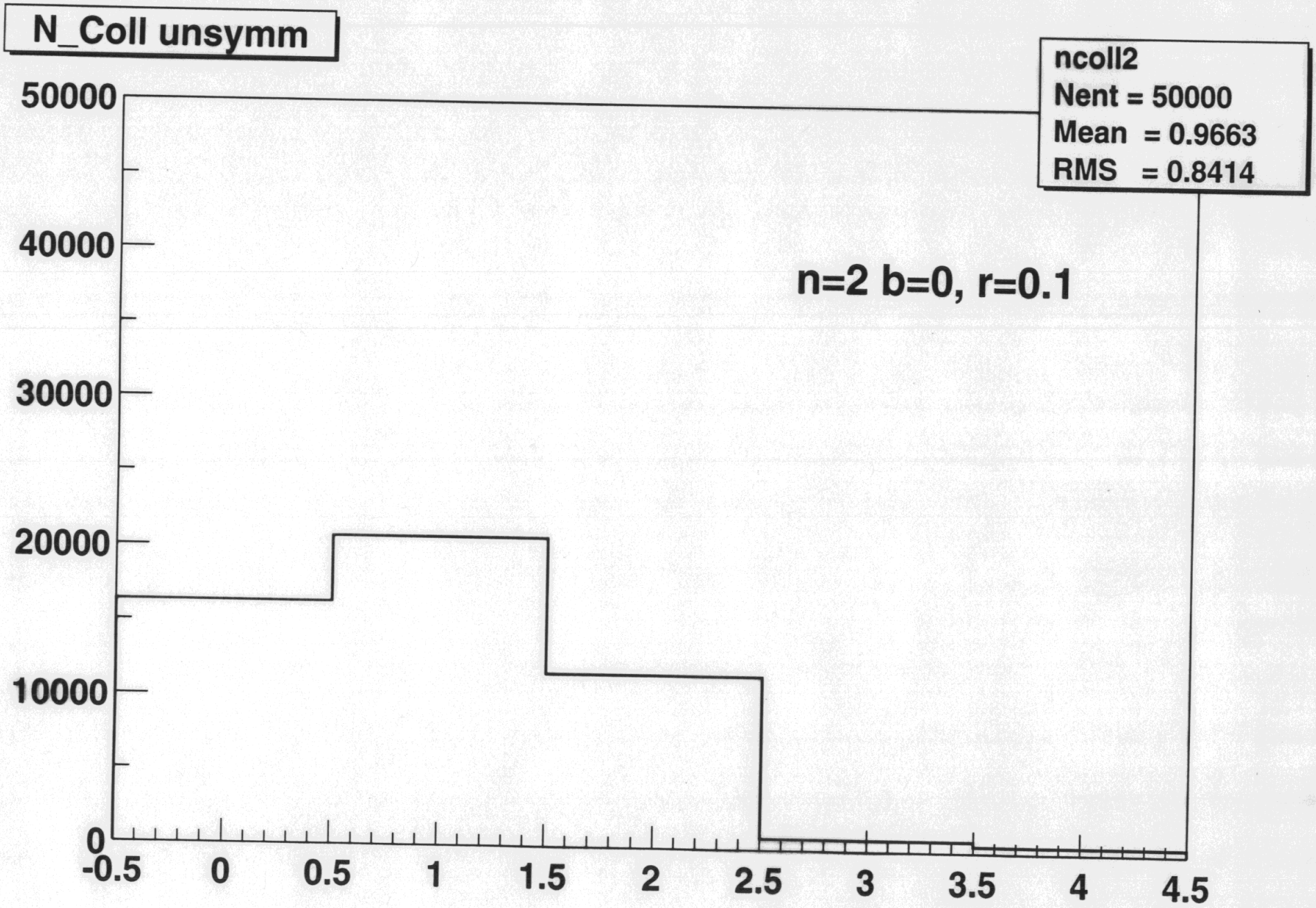


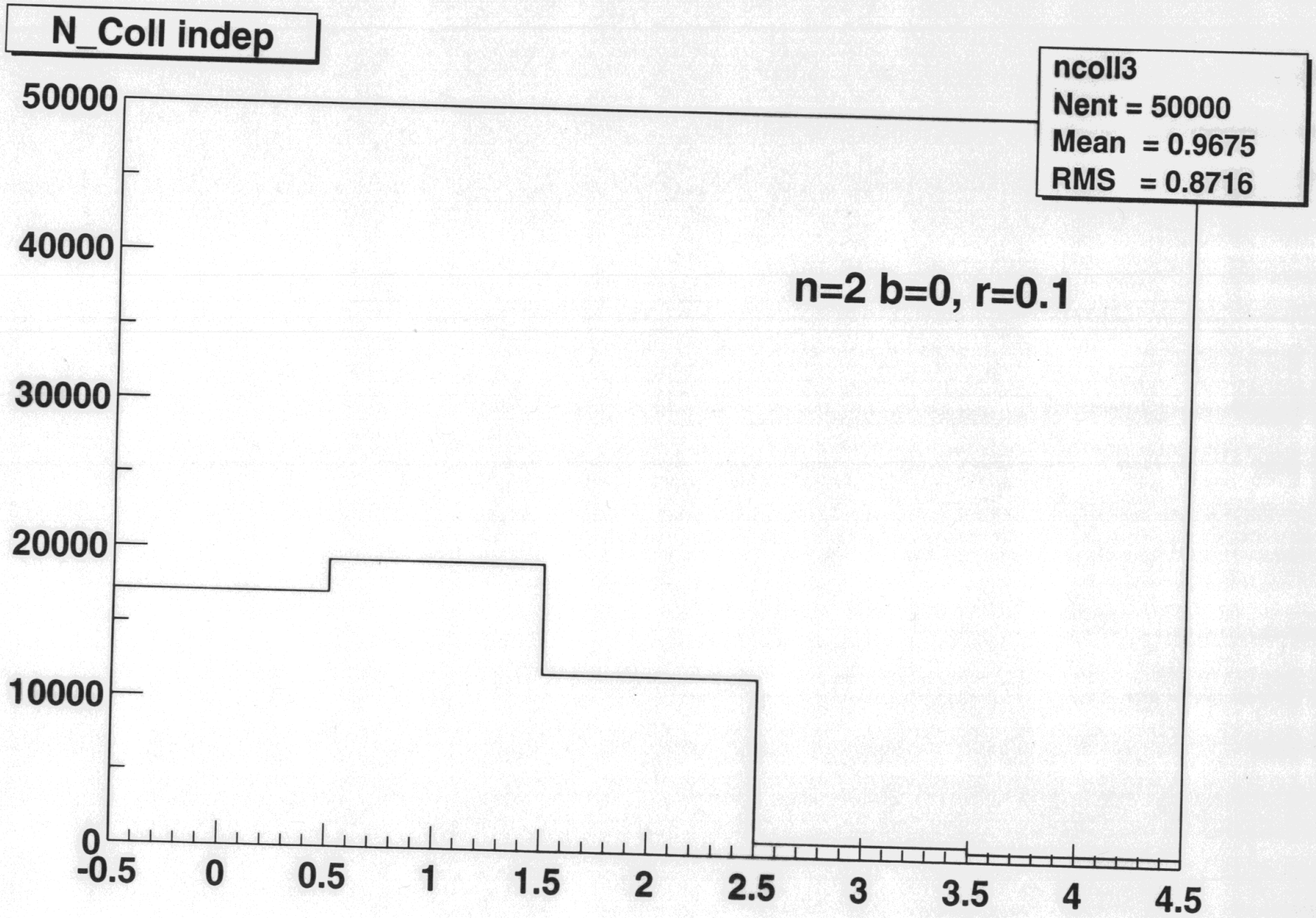

Unsym 1-d Density
densUnsym
Nent = 200000
Mean = 0.5006
RMS = 0.2273
6000
5000
4000
3000
2000
1000
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

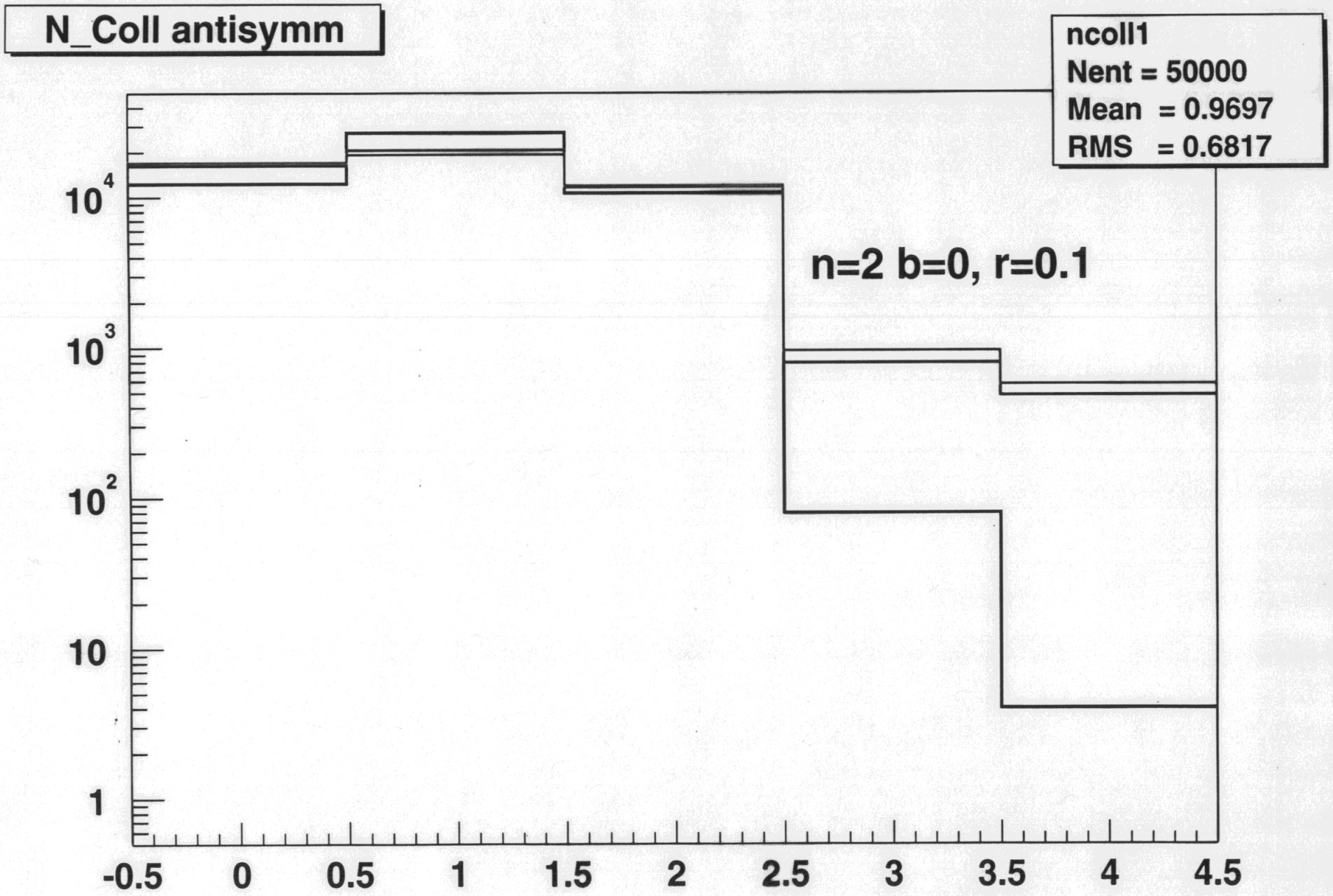

x1:x2 {type==3}
Independent
1
0.8
0.6
0.4
0.2
0
0
0.2
0.4
0.6
0.8
1

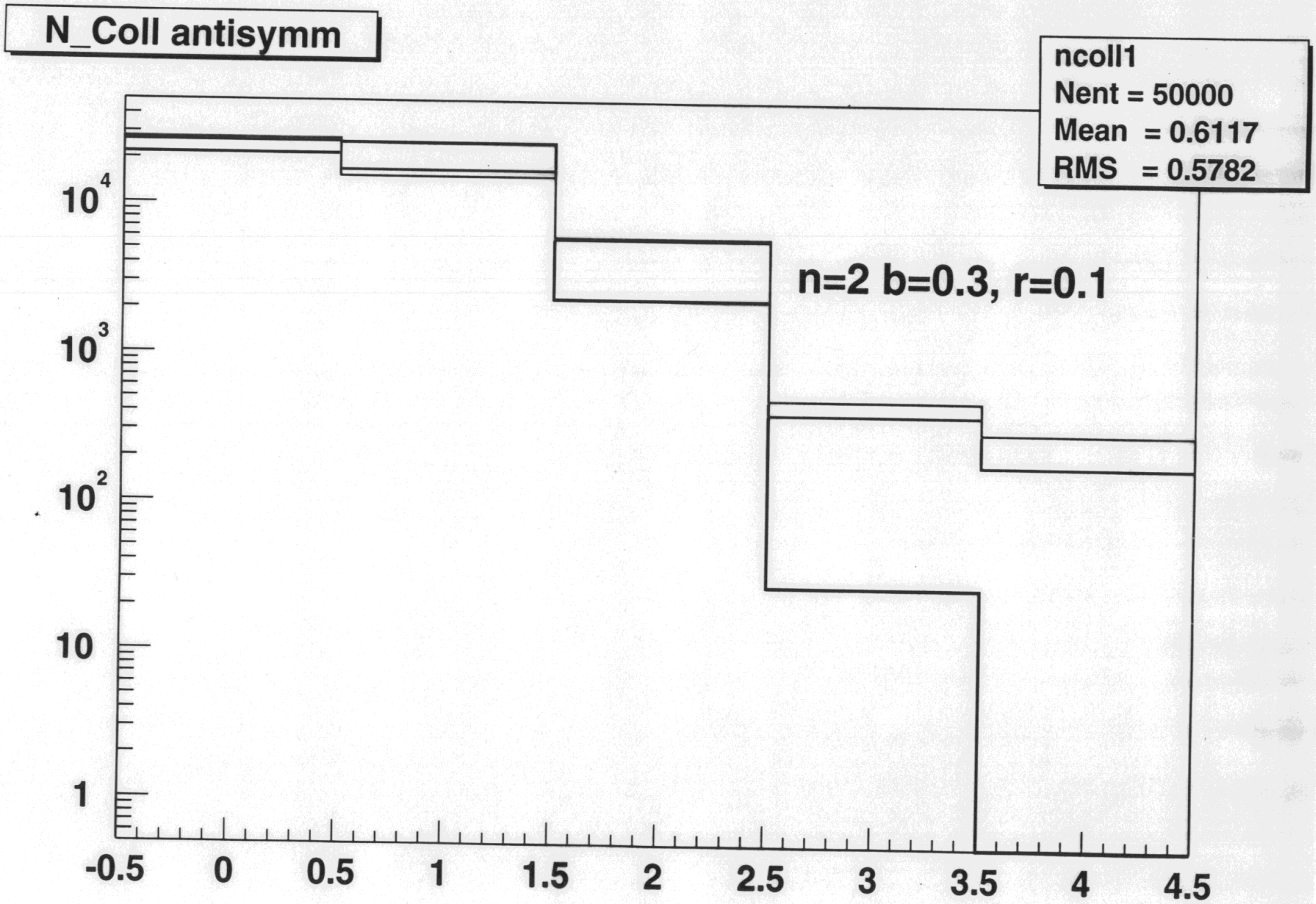

Indep 1-d Density
densIndep
Nent = 200000
Mean = 0.4991
RMS = 0.2275
6000
5000
4000
3000
2000
1000
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

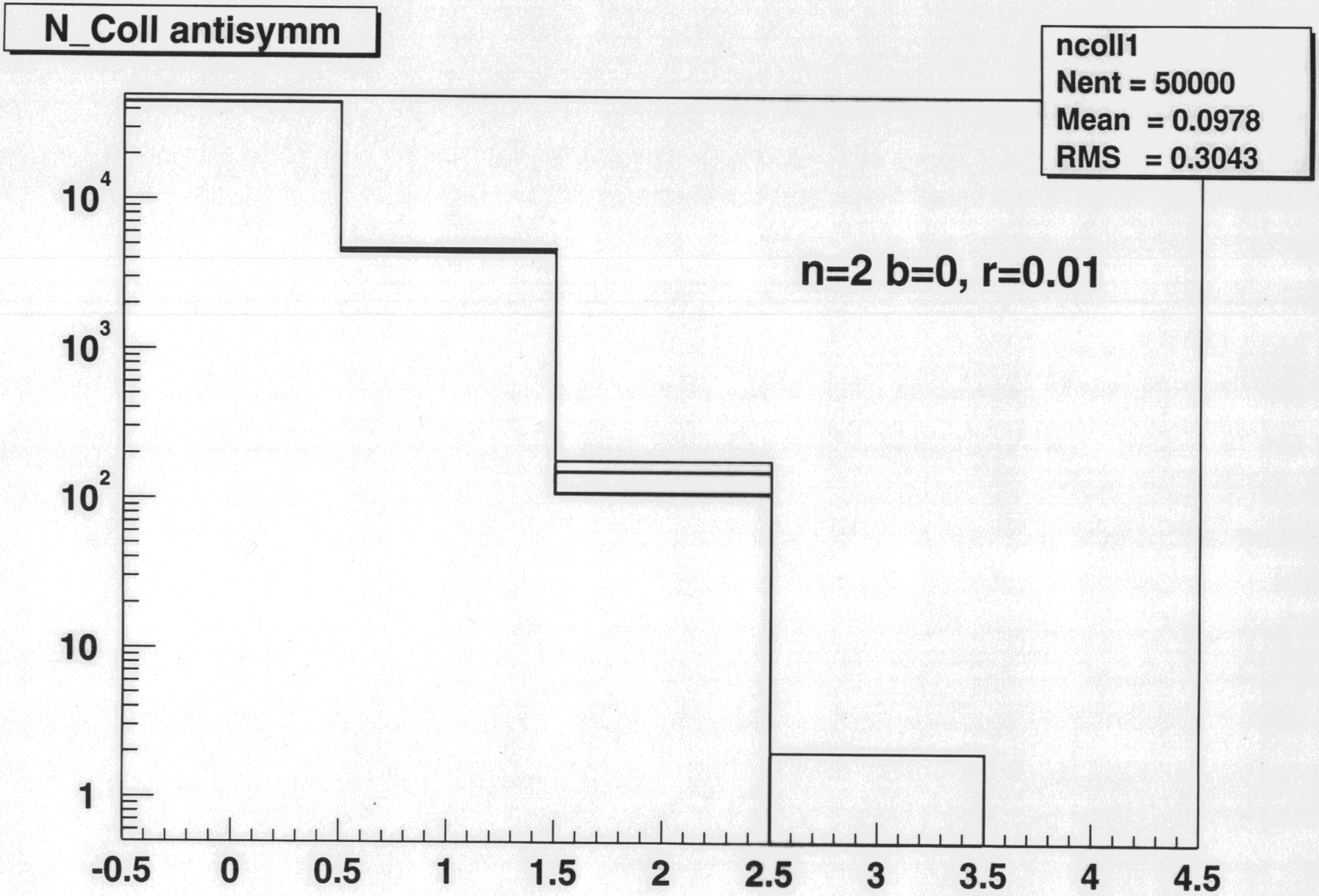

N_Coll antisymm
ncoll1
Nent = 50000
Mean = 0.9697
RMS = 0.6817
n=2 b=0, r=0.1
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
-0.5
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5

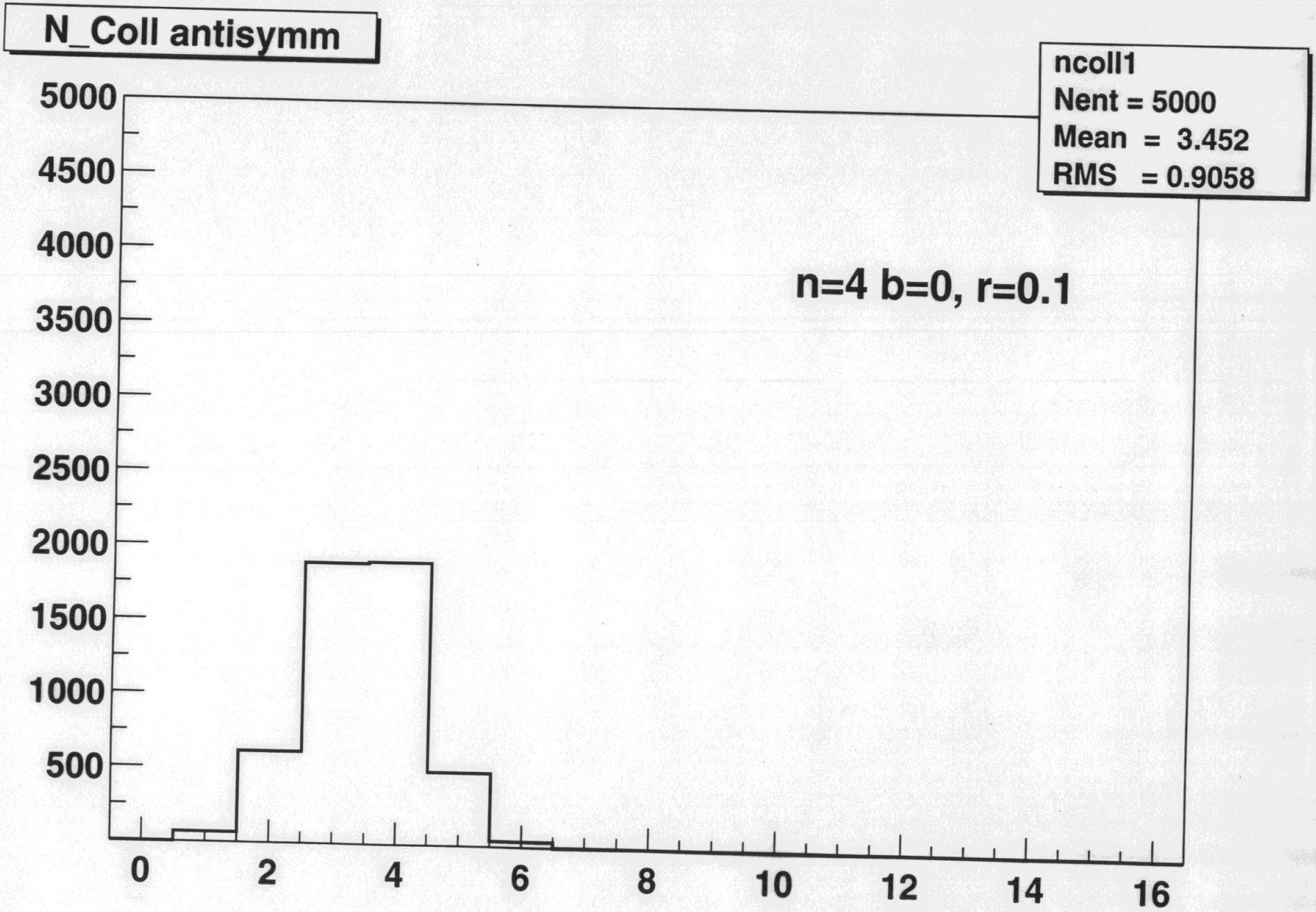

N_Coll unsymm
ncoll2
Nent = 50000
Mean = 0.9663
RMS = 0.8414
n=2 b=0, r=0.1
50000
40000
30000
20000
10000
0
-0.5
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5

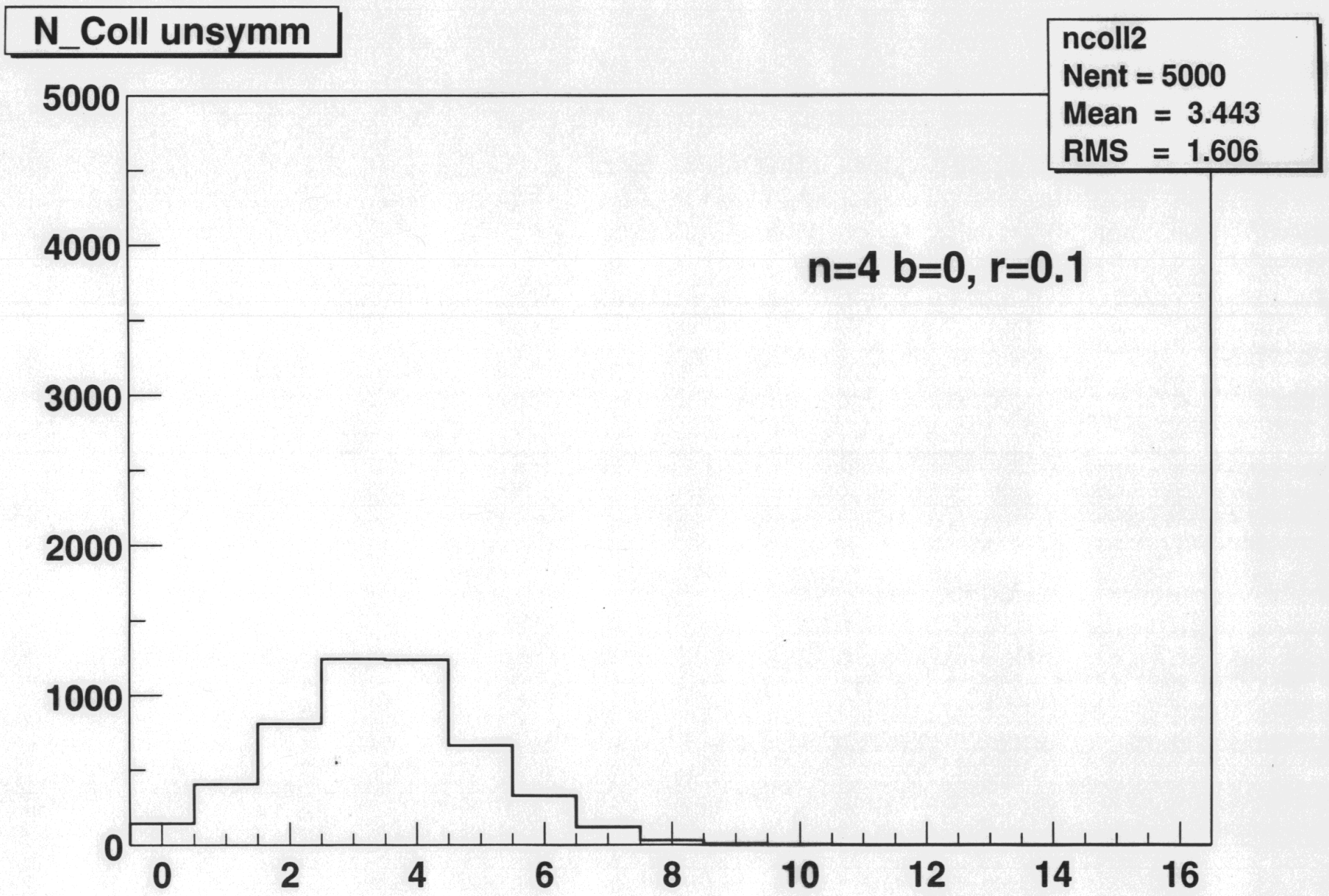

N_Coll indep
ncoll3
Nent = 50000
Mean = 0.9675
RMS = 0.8716
n=2 b=0, r=0.1
50000
40000
30000
20000
10000
0
-0.5
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5

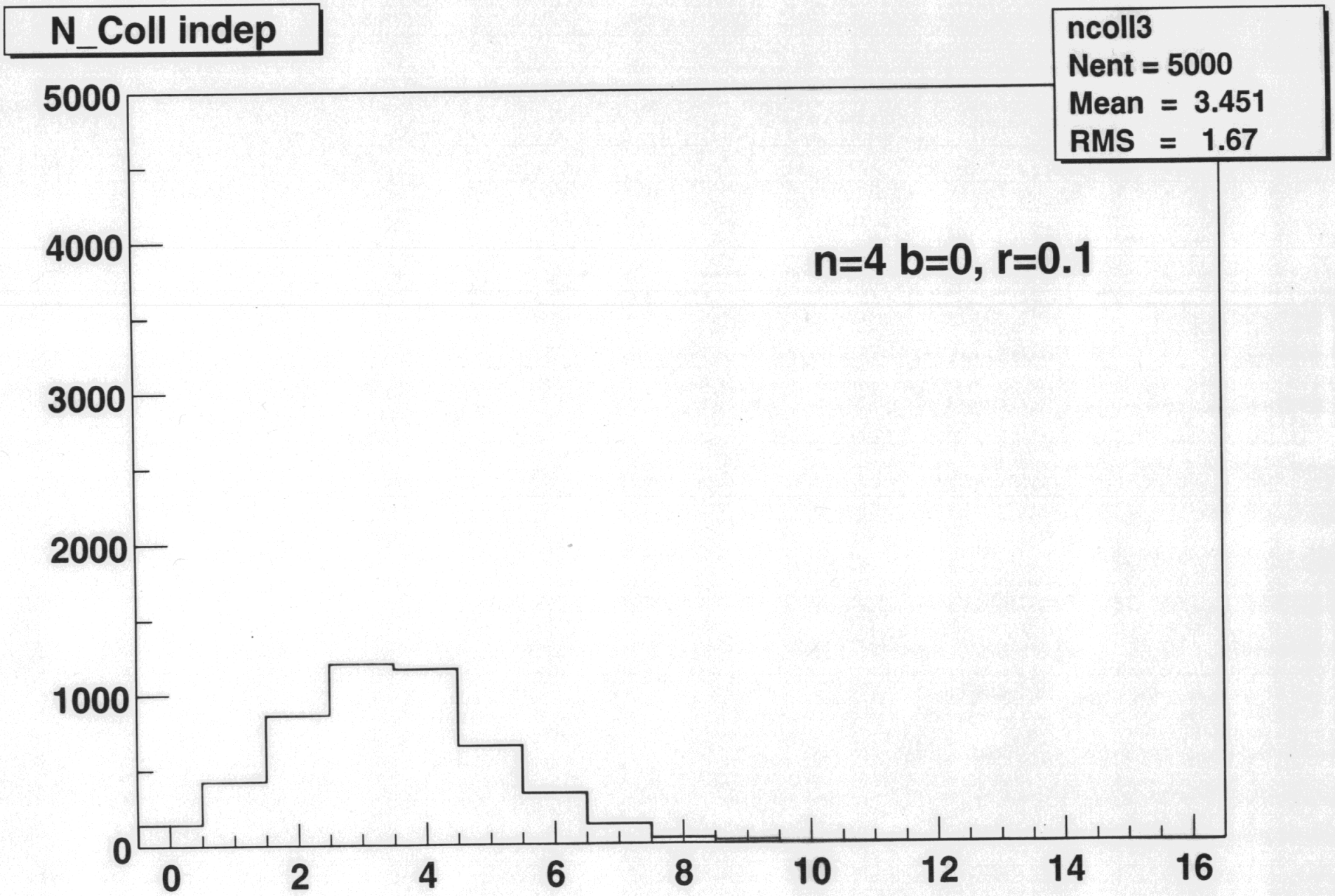

N_Coll antisymm
ncoll1
Nent = 50000
Mean = 0.9697
RMS = 0.6817
n=2 b=0, r=0.1
10^4
10^3
10^2
10
1
-0.5
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5

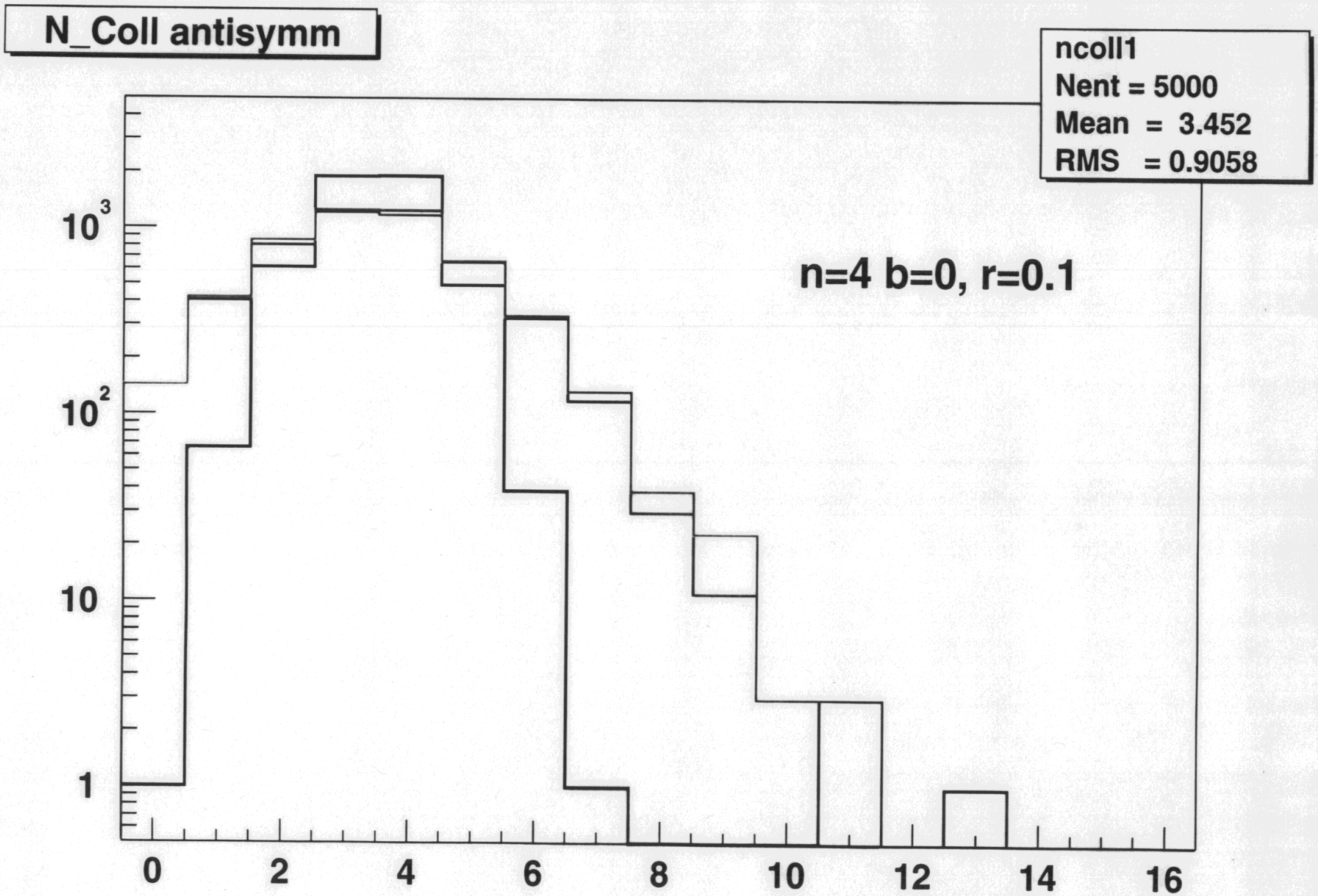

N_Coll antisymm
ncoll1
Nent = 50000
Mean = 0.6117
RMS = 0.5782
n=2 b=0.3, r=0.1
10^4
10^3
10^2
10
1
-0.5
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5

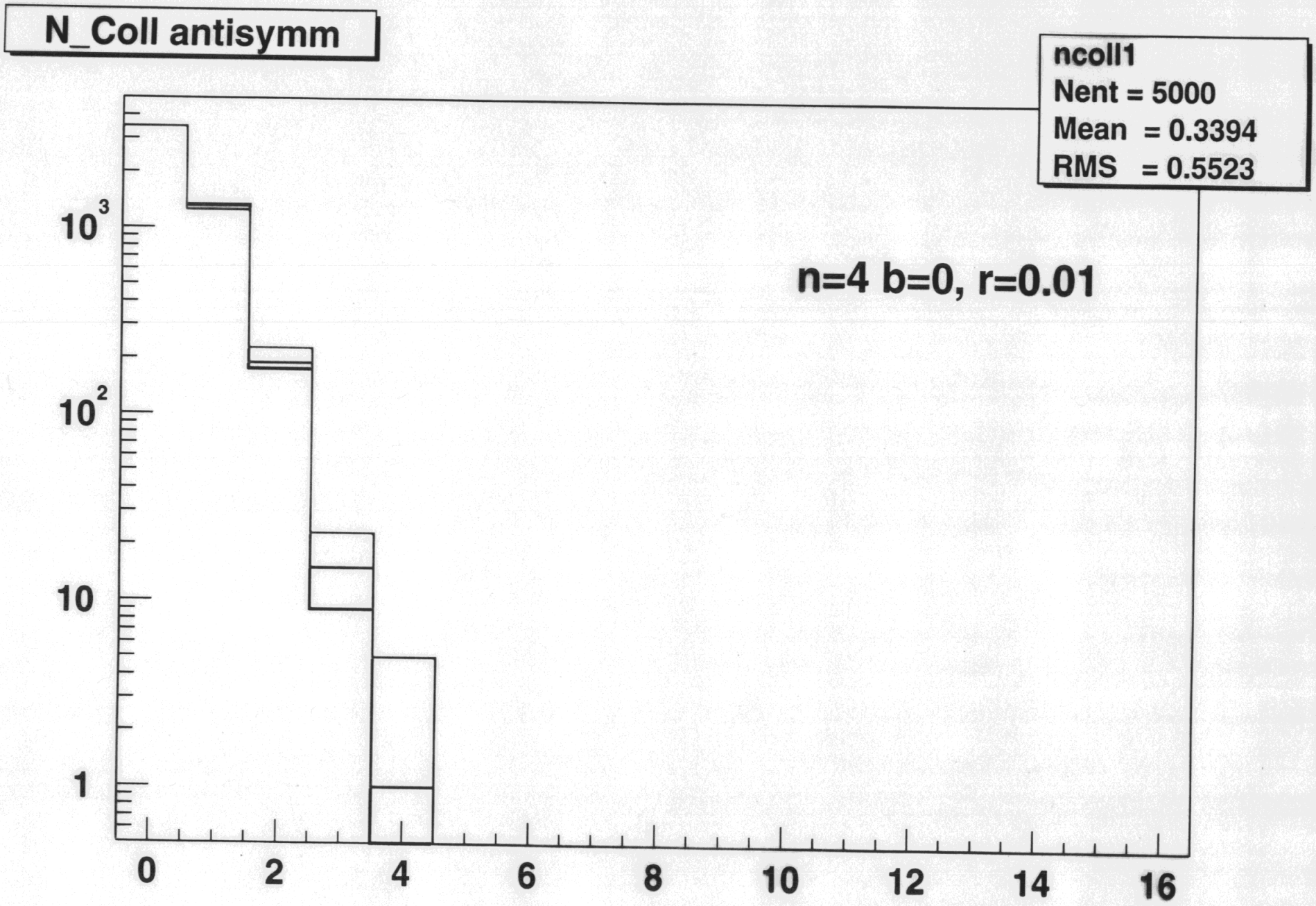

N_Coll antisymm
ncoll1
Nent = 50000
Mean = 0.0978
RMS = 0.3043
n=2 b=0, r=0.01
10^4
10^3
10^2
10
1
-0.5
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5

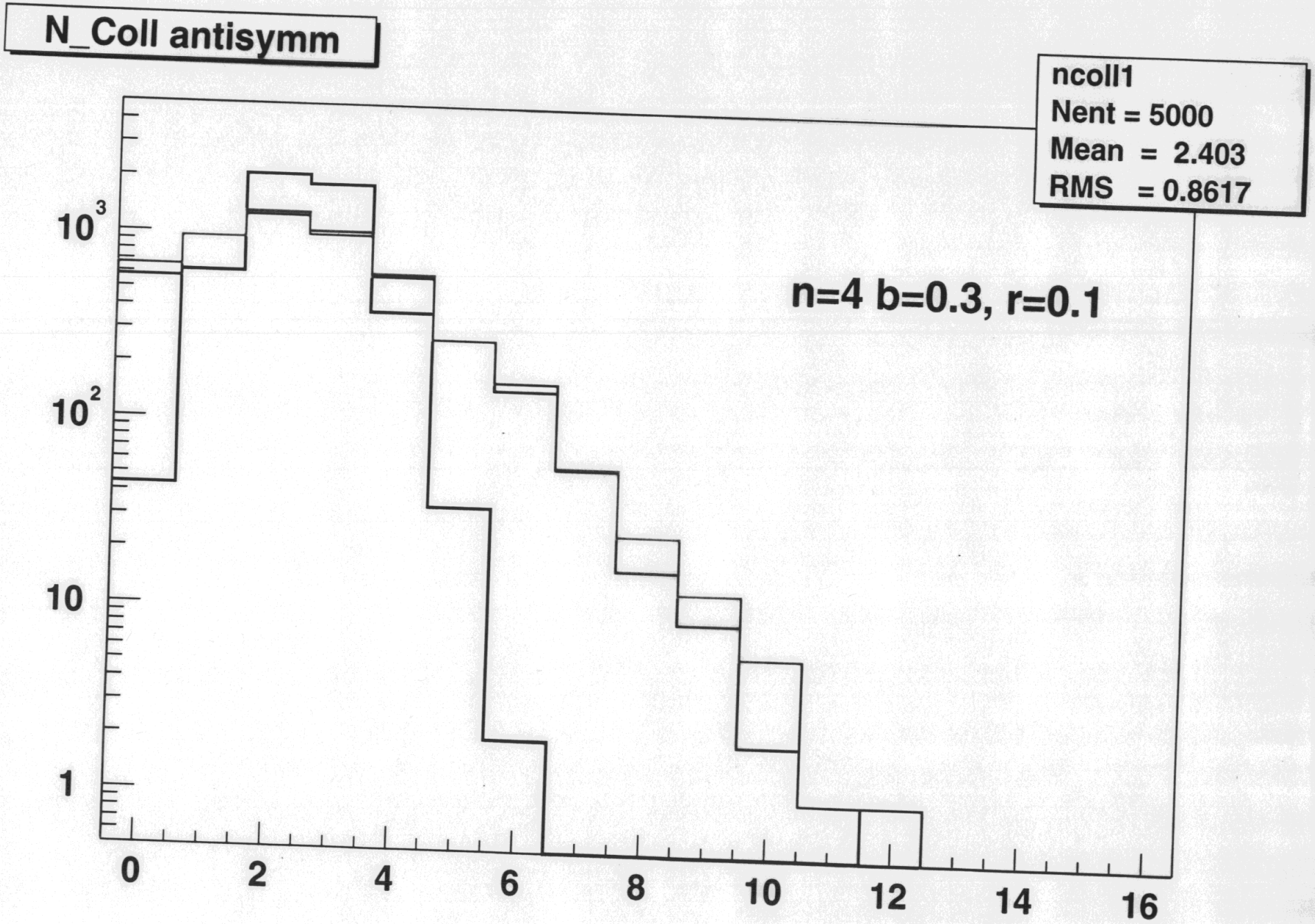

N_Coll antisymm
ncoll1
Nent = 5000
Mean = 3.452
RMS = 0.9058
n=4 b=0, r=0.1
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
2
4
6
8
10
12
14
16


N_Coll unsymm
ncoll2
Nent = 5000
Mean = 3.443
RMS = 1.606
n=4 b=0, r=0.1
5000
4000
3000
2000
1000
0
0
2
4
6
8
10
12
14
16


N_Coll indep
ncoll3
Nent = 5000
Mean = 3.451
RMS = 1.67
n=4 b=0, r=0.1
5000
4000
3000
2000
1000
0
0
2
4
6
8
10
12
14
16


N_Coll antisymm
ncoll1
Nent = 5000
Mean = 3.452
RMS = 0.9058
n=4 b=0, r=0.1
10^3
10^2
10
1
0
2
4
6
8
10
12
14
16


N_Coll antisymm
ncoll1
Nent = 5000
Mean = 0.3394
RMS = 0.5523
n=4 b=0, r=0.01
10^3
10^2
10
1
0
2
4
6
8
10
12
14
16


N_Coll antisymm
ncoll1
Nent = 5000
Mean = 2.403
RMS = 0.8617
n=4 b=0.3, r=0.1
10^3
10^2
10
1
0
2
4
6
8
10
12
14
16